Jun 6th, 2:30 PM - 2:50 PM

Session B5 - The effect of temperature and ammonia exposure on swimming performance of brook charr (Salvelinus fontinalis)

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Effects of Temperature and Ammonia on Swimming Capacity

C. Tudorache, R.A. O'Keefe, T.J. Benfey
University of New Brunswick

Migration

Very common

Genetic variation and fitness

Ontogeny

Migration

Human activity: impacts on the environment

Dredging streams, building dams, weirs

Impassable for migrating fish

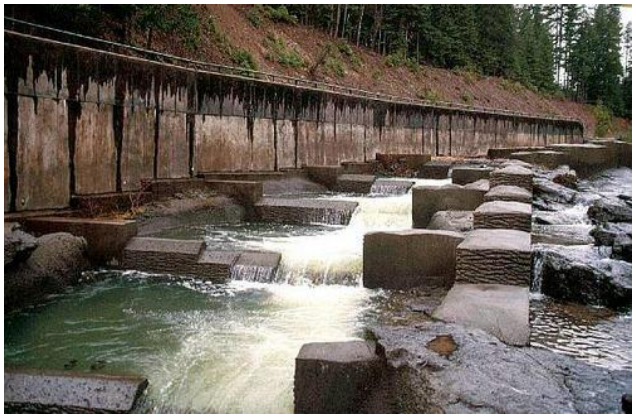
Disturbance of communities, local extinction of populations, species

Migration

Solution:

Fish stairs

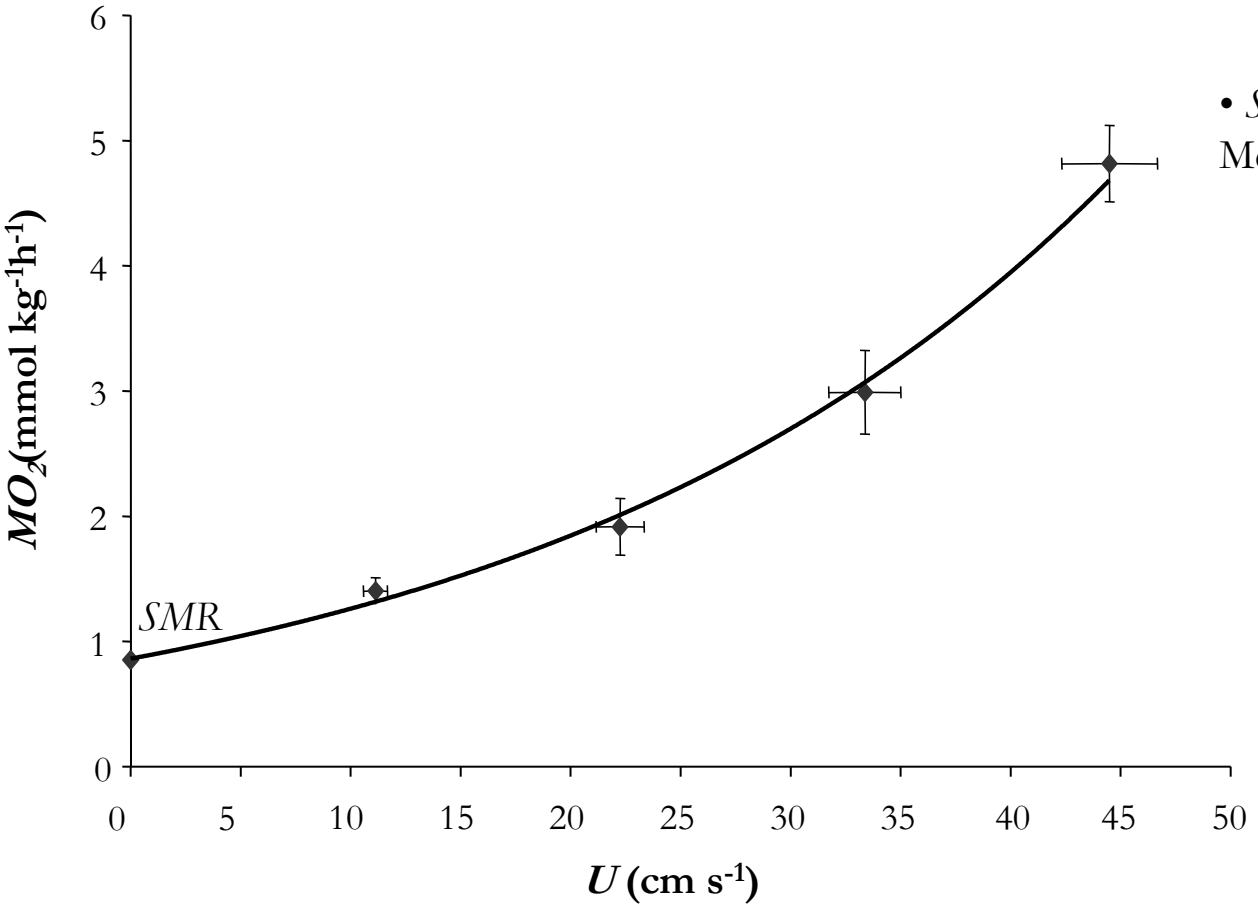
Culverts



Fish passages

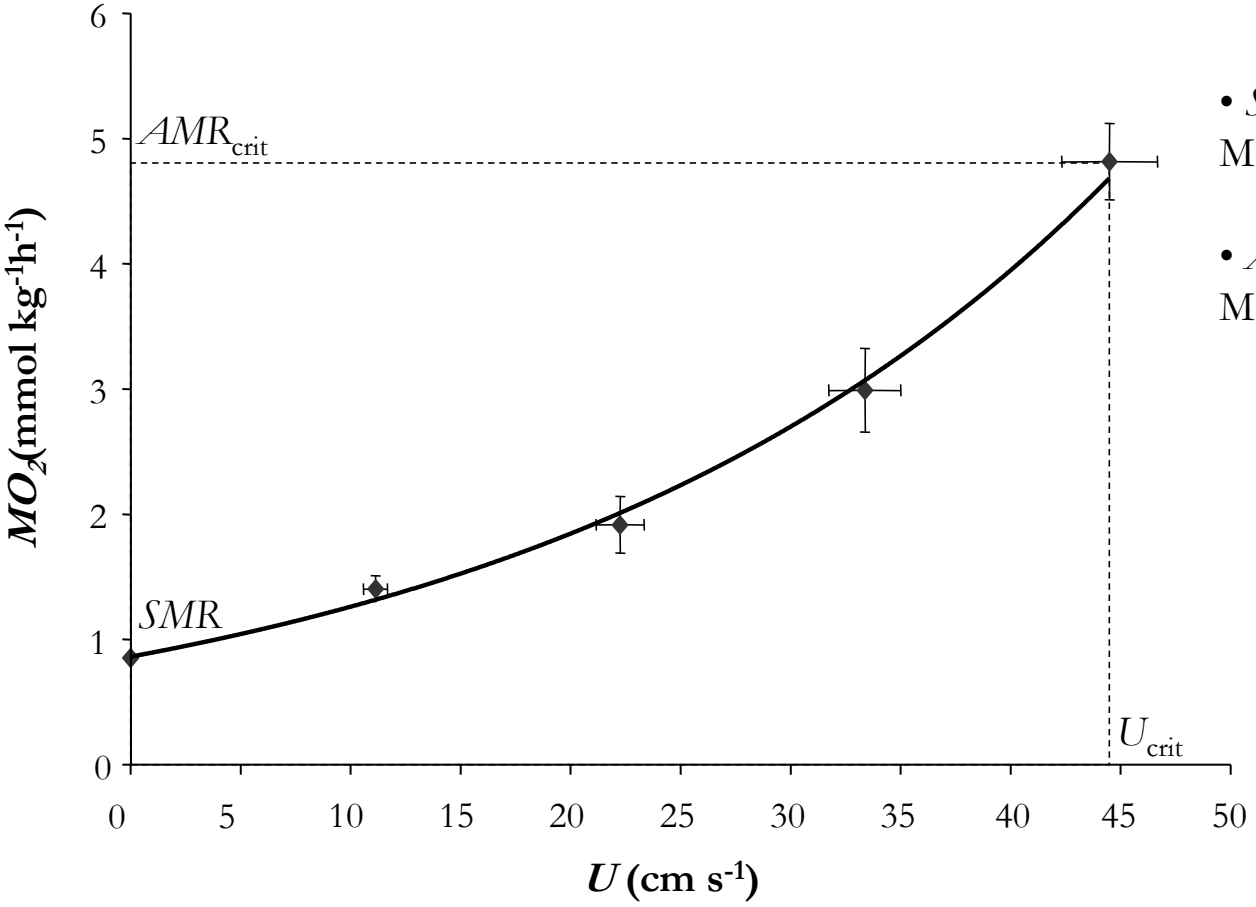
Design based on swimming physiology

Physiology



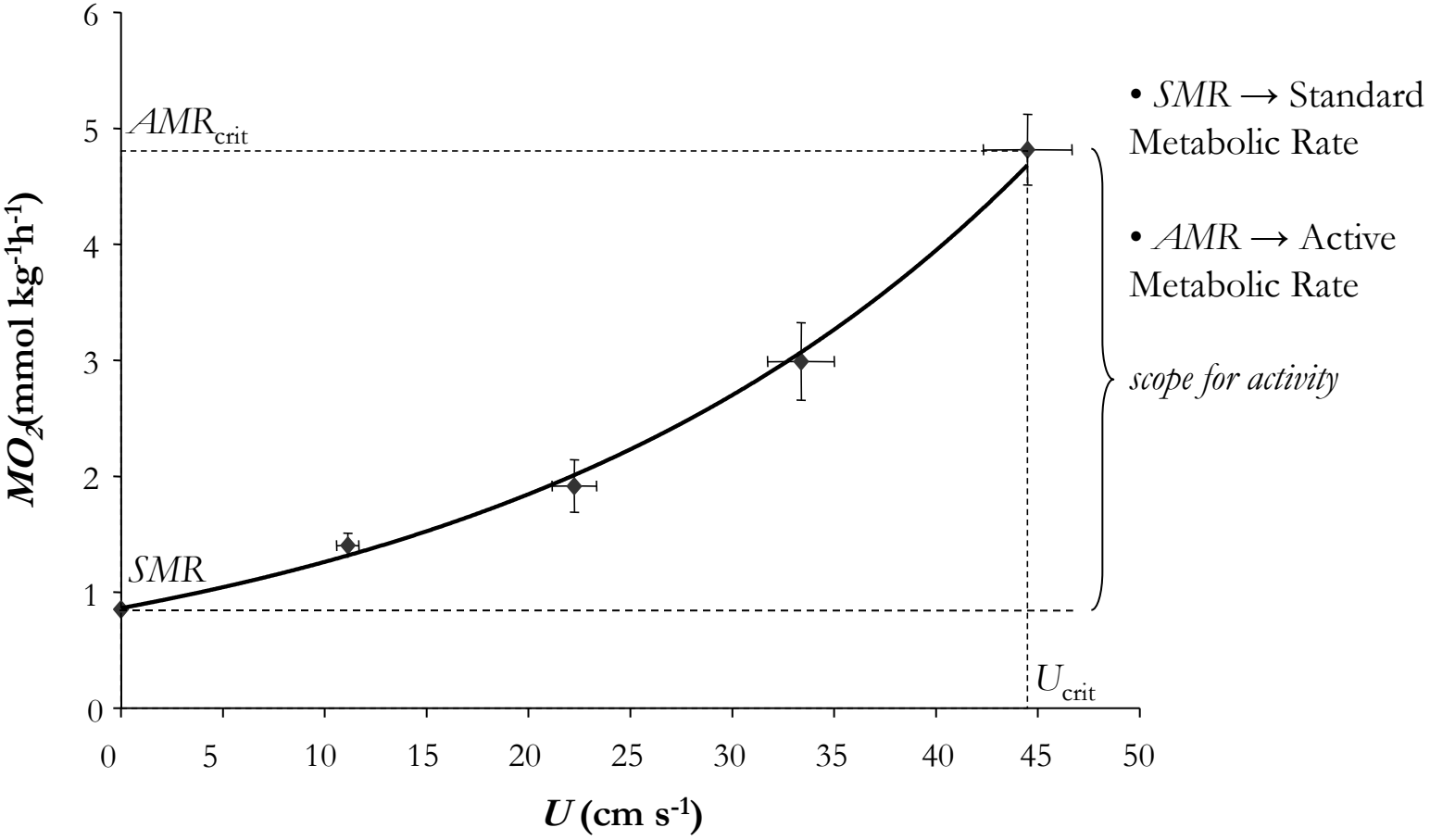
- *SMR* → Standard Metabolic Rate

Physiology

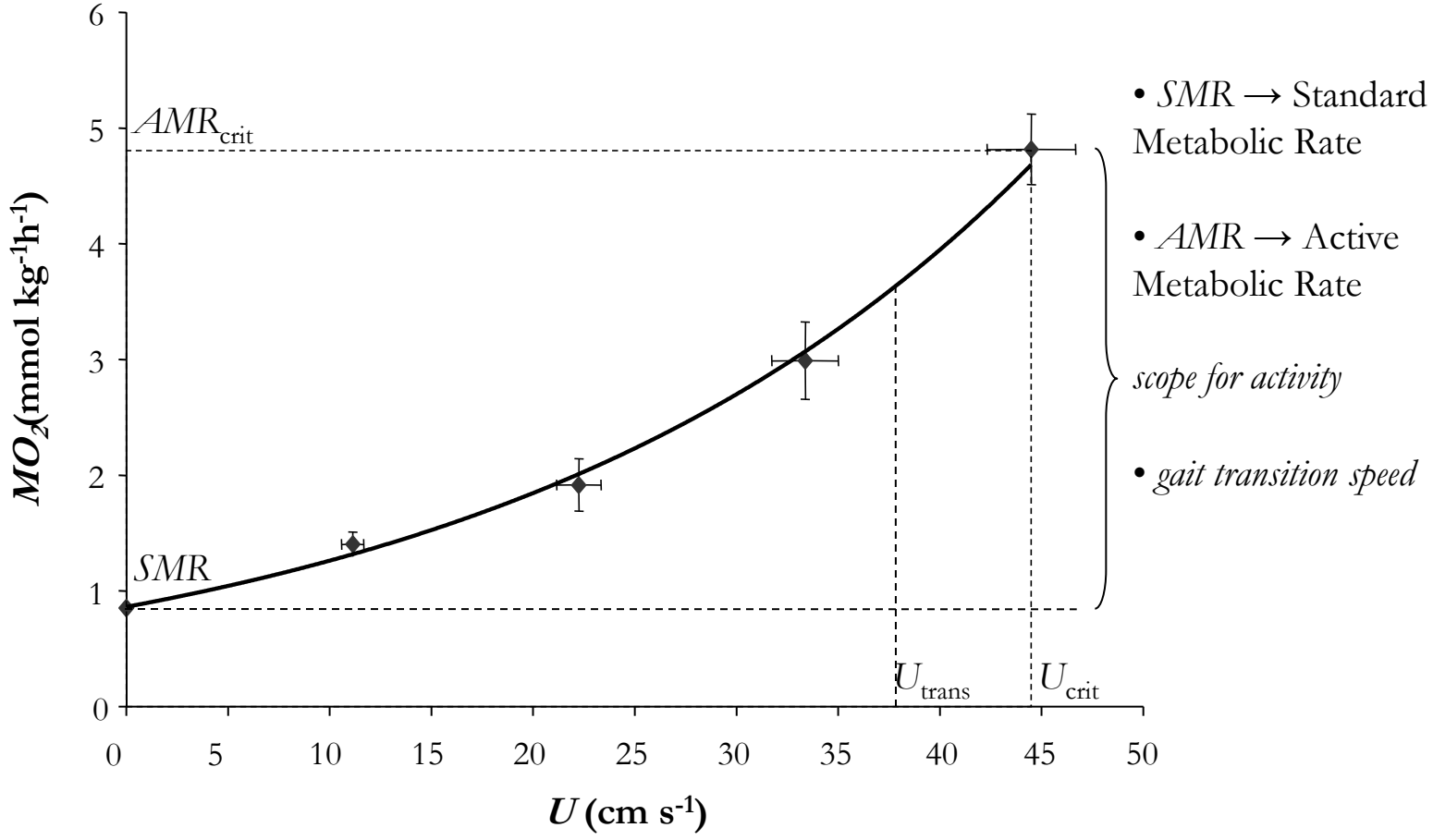


- *SMR* → Standard Metabolic Rate
- *AMR* → Active Metabolic Rate

Physiology


AMR_{crit}
SMR
U_{crit}
MO_2 (mmol kg^{-1}h^{-1})
U (cm s^{-1})
0
1
2
3
4
5
6
0
5
10
15
20
25
30
35
40
45
50
• *SMR* → Standard Metabolic Rate
• *AMR* → Active Metabolic Rate
scope for activity

Physiology


MO_2(mmol kg^{-1}h^{-1})
AMR_{crit}
SMR
U_{trans}
U_{crit}
U (cm s^{-1})
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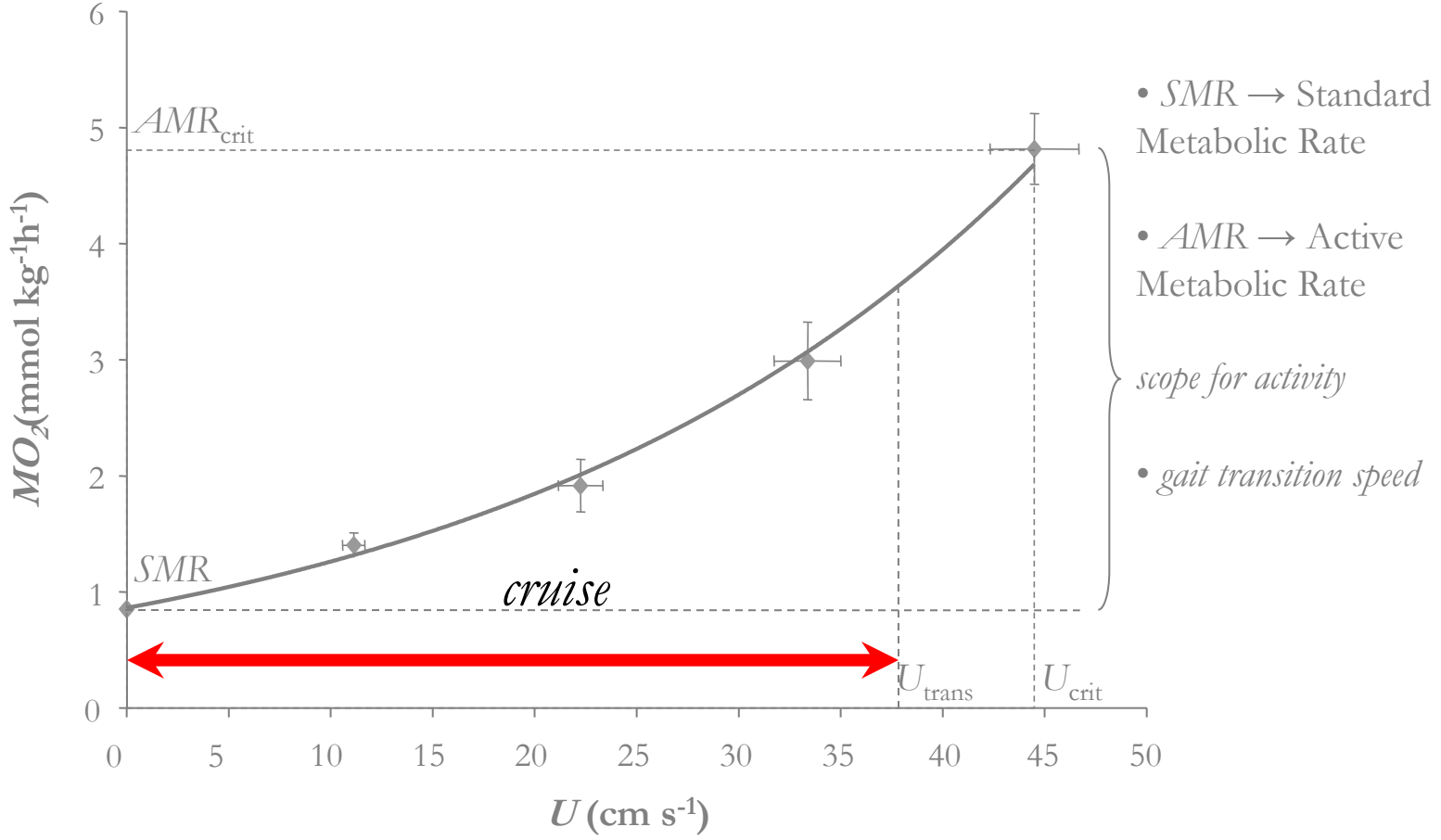
scope for activity
• *gait transition speed*

Physiology


AMR_{crit}
SMR
cruise
U_{trans}
U_{crit}
MO_2 (mmol $kg^{-1}h^{-1}$)
U (cm s^{-1})
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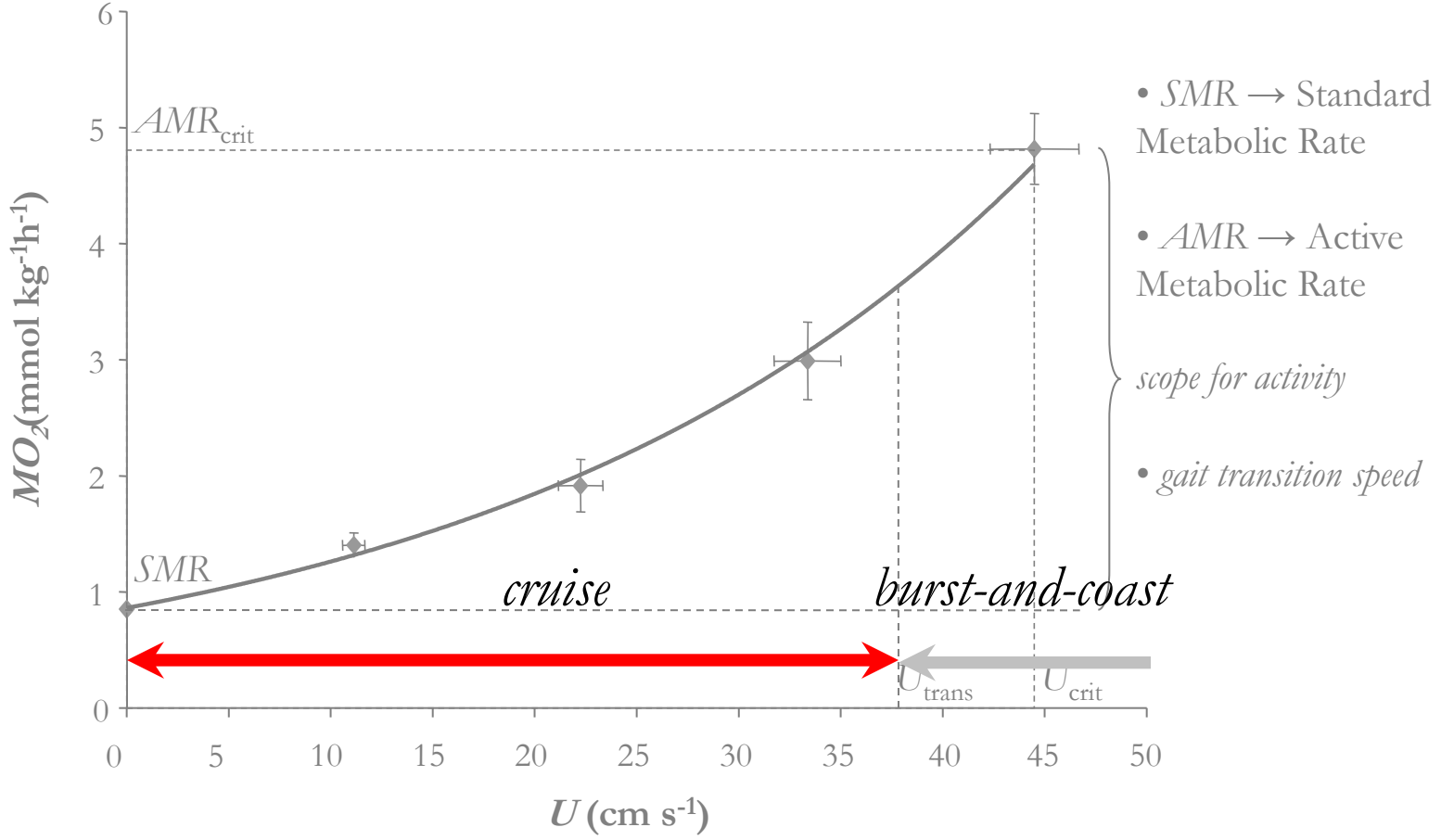
Physiology


AMR_{crit}
SMR
cruise
burst-and-coast
U_{trans}
U_{crit}
MO_2 (mmol $kg^{-1}h^{-1}$)
U (cm s^{-1})
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scope for activity
• *gait transition speed*

Introduction

Critical swimming speed (U_{crit})

Importance for general physiology

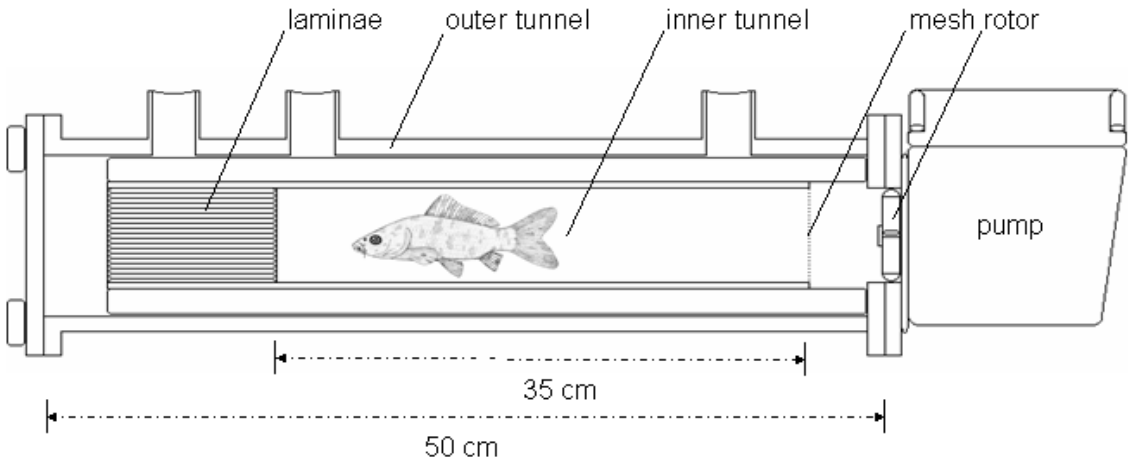
Indicator for maximum sustainable oxygen uptake

Combines cruise and burst-and-coast swimming

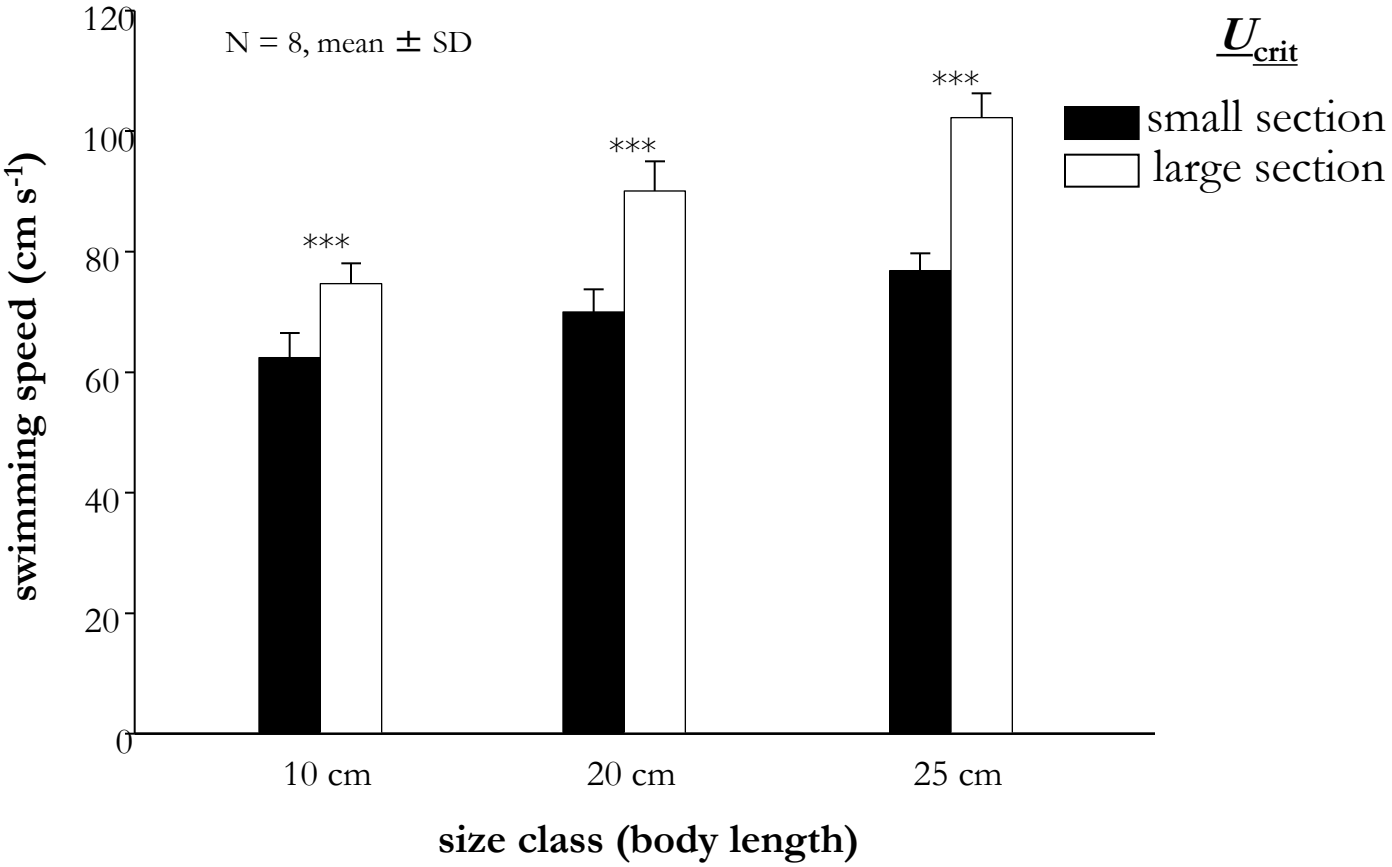
Maximum water velocity in flumes and culverts

Tested in swimming tunnel

Swimming Tunnel

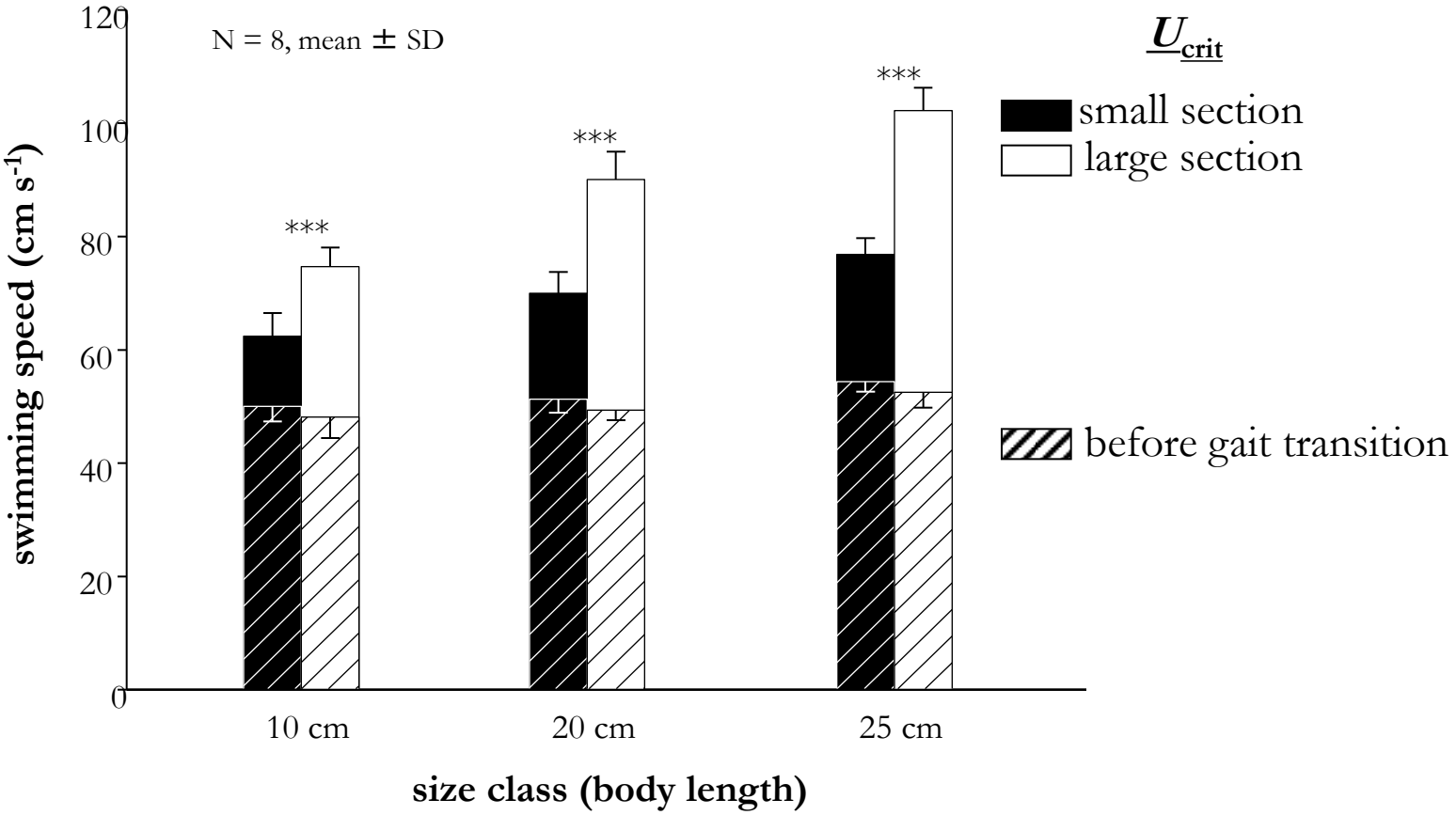


Swimming Tunnel



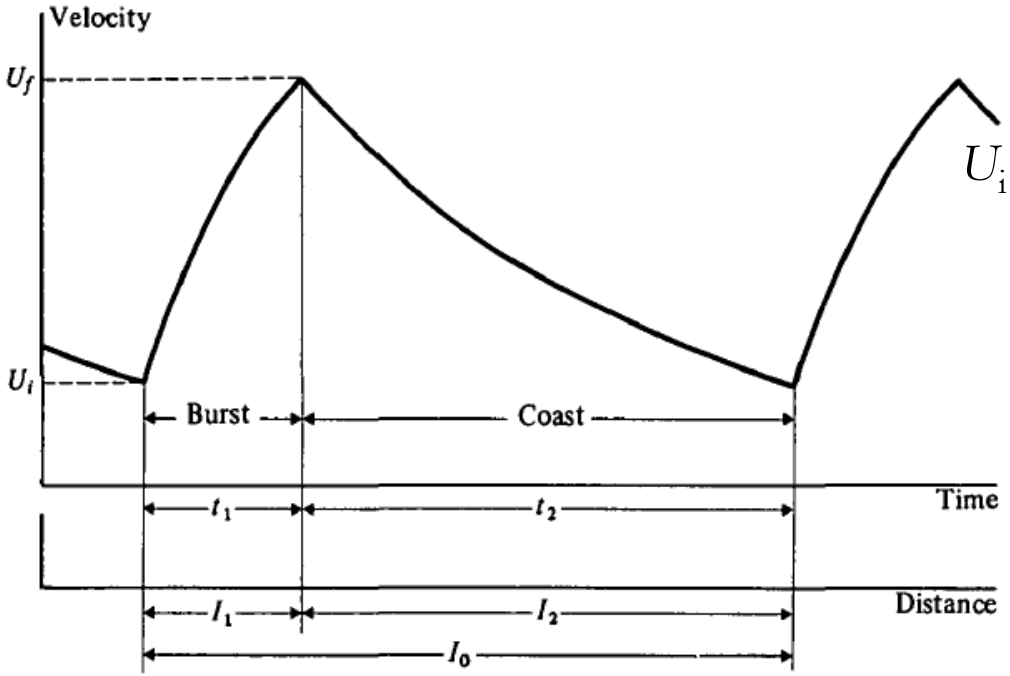
Tudorache *et al.*, 2007

Swimming Tunnel



Tudorache *et al.*, 2007

Burst-and-Coast Swimming



form: Videler & Weihs, 1981

Burst phase

U_i → initial velocity; burst phase starts off

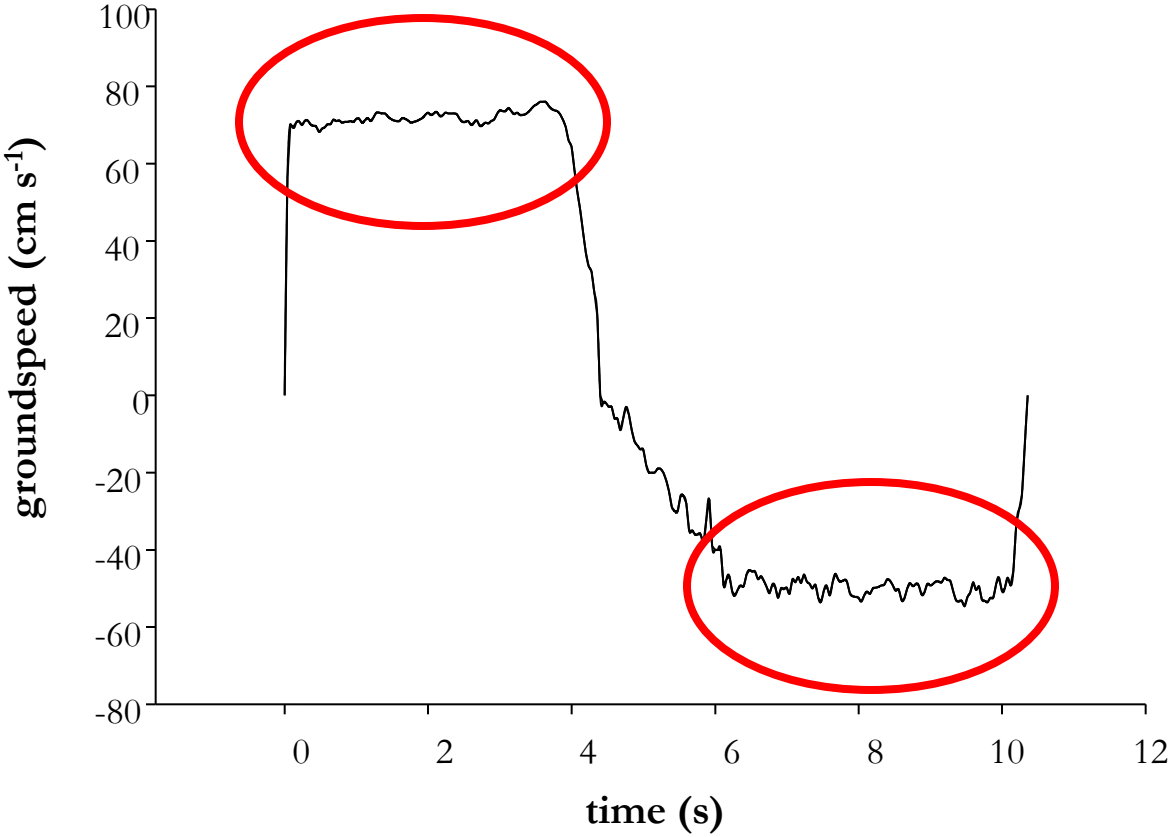
U_f → final velocity; fish accelerates

Coast phase

Deceleration to U_i

50% less energy than steady swimming (Weihs, 1974)

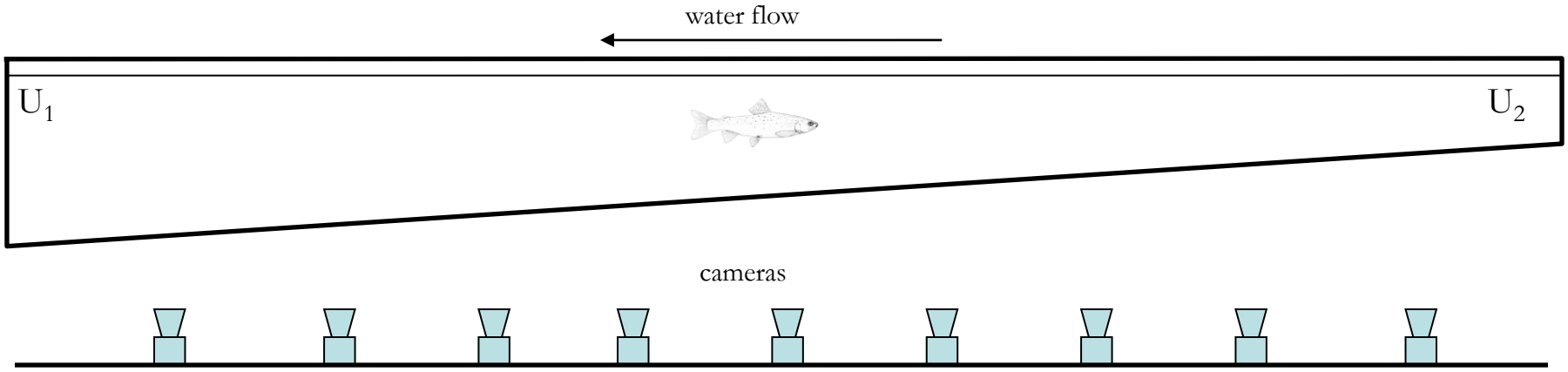
Burst-and-Coast Swimming



U_{crit} volitional aspect, behaviourally biased set-up alters results

Alternative: gait transition speed (U_{trans})

Tilted Flume (Peake & Farrell, 2003)



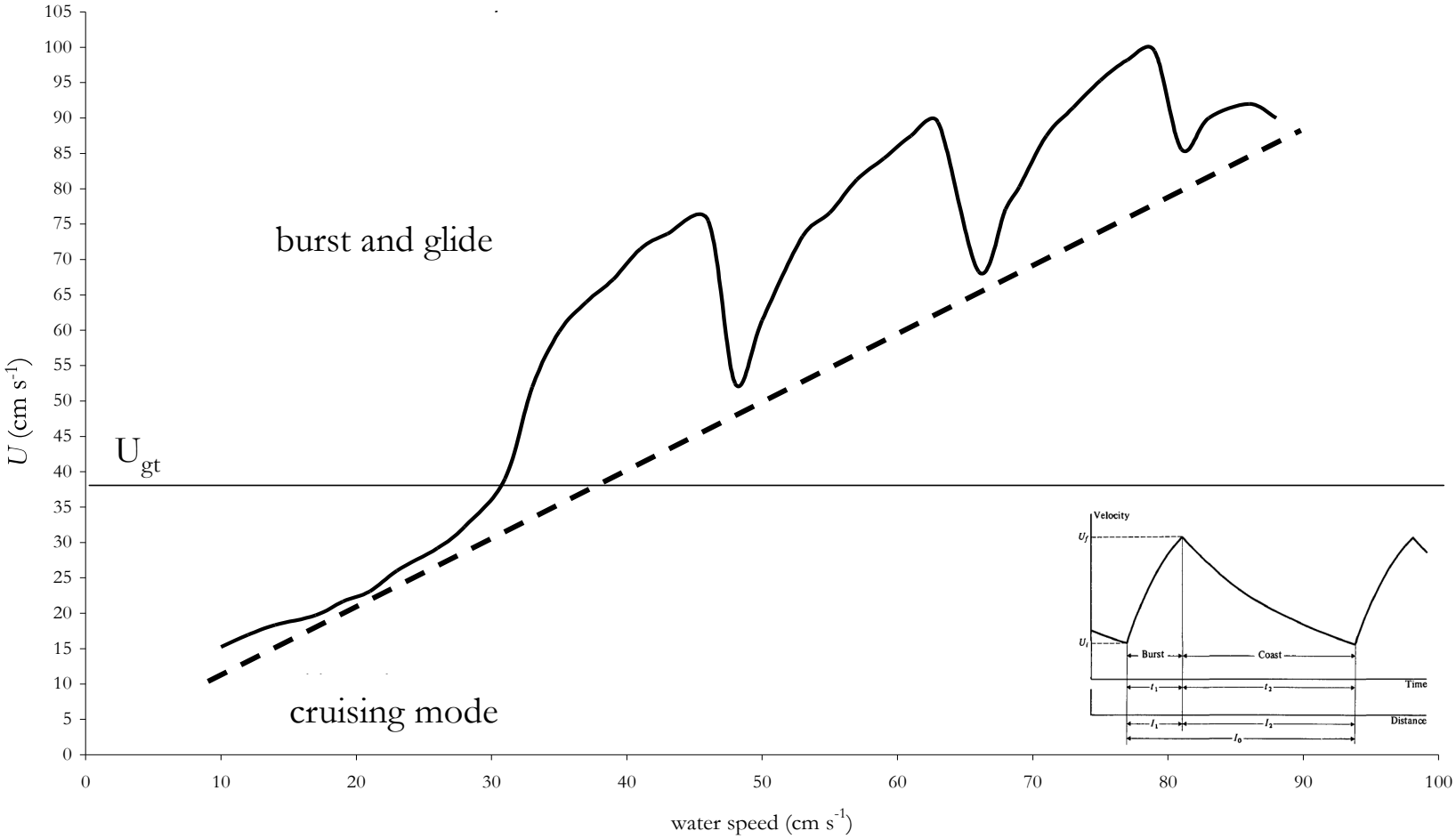
$$Q = A\,U$$

$$U = Q\,A^{-1}$$

$$U_1 < U_2,\ 5 - 120\ cm\ s^{-1}$$

Methods

Swimming Pattern



swimming parameters:

gait transition speed (U_{trans}, cm s^{-1}),

maximum burst speed (U_{max}, cm s^{-1}),

tail-beat amplitude (a, cm),

tail-beat frequency (f, Hz),

maximum acceleration of bursts (A_{max}, cm s^{-2})

temperature: 10, 15 (acclimation), 20°C

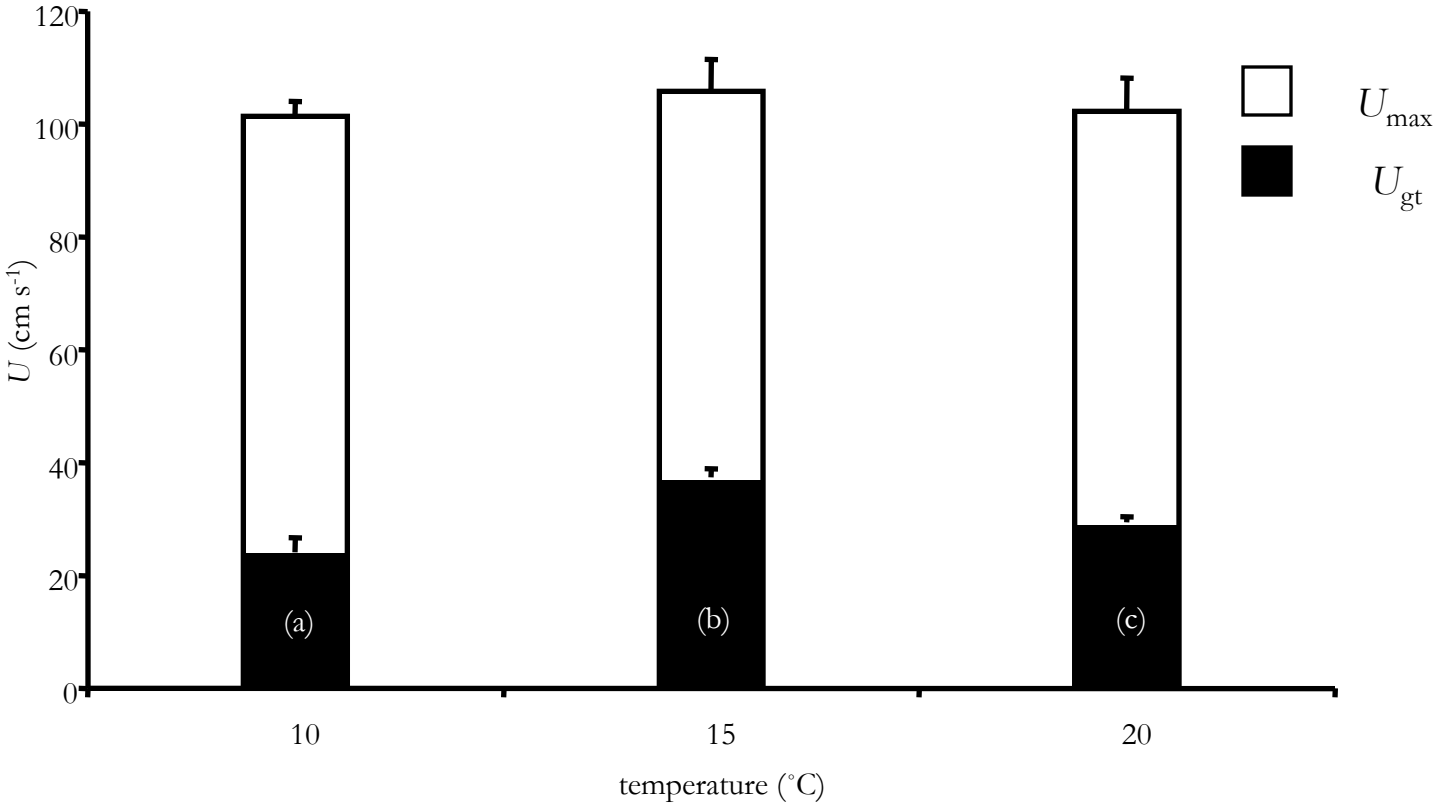
effect on aerobic swimming

ammonia: 0, 14.38, 28.76, 43.14, 57.53 µmol l^{-1}

effect on anaerobic swimming

Results

Velocity



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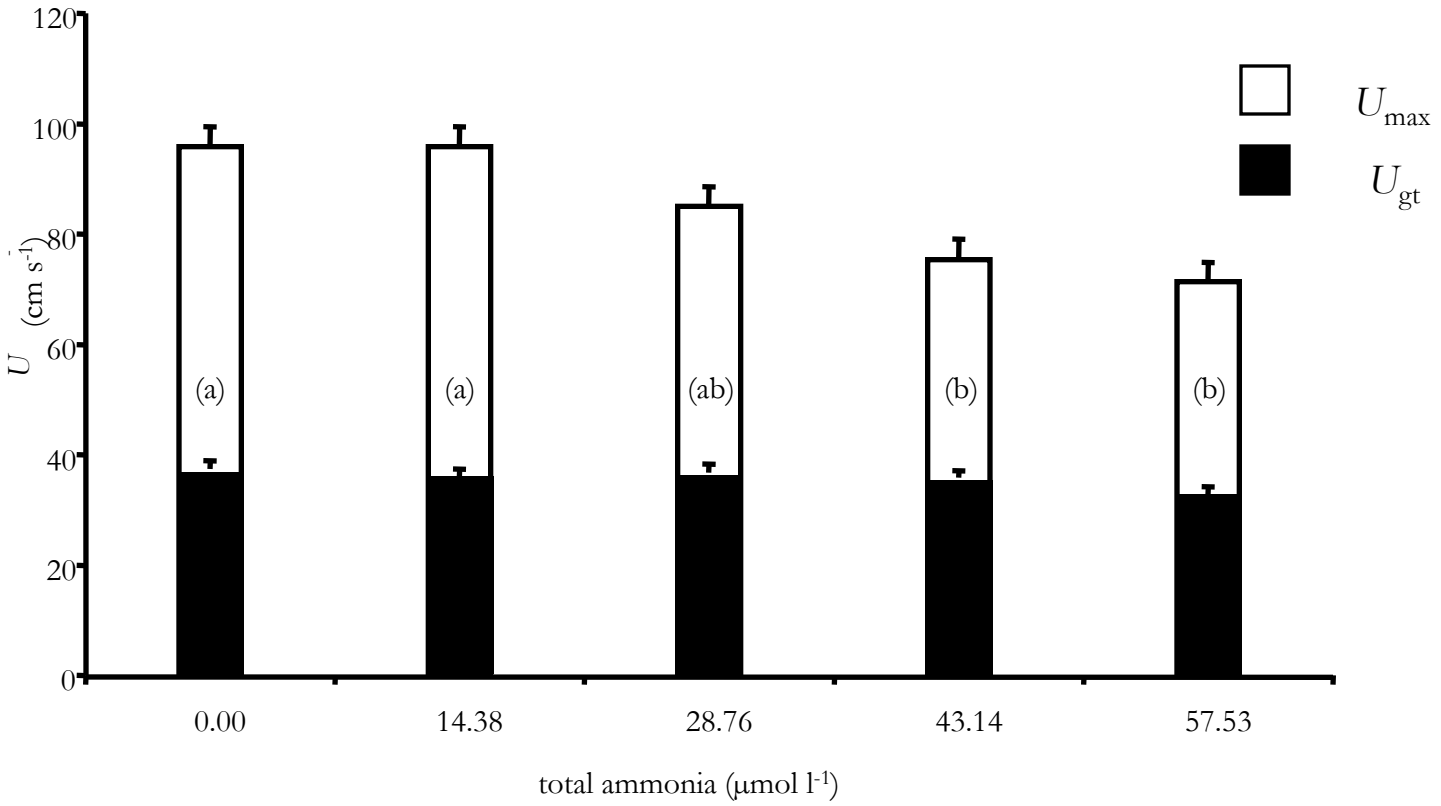
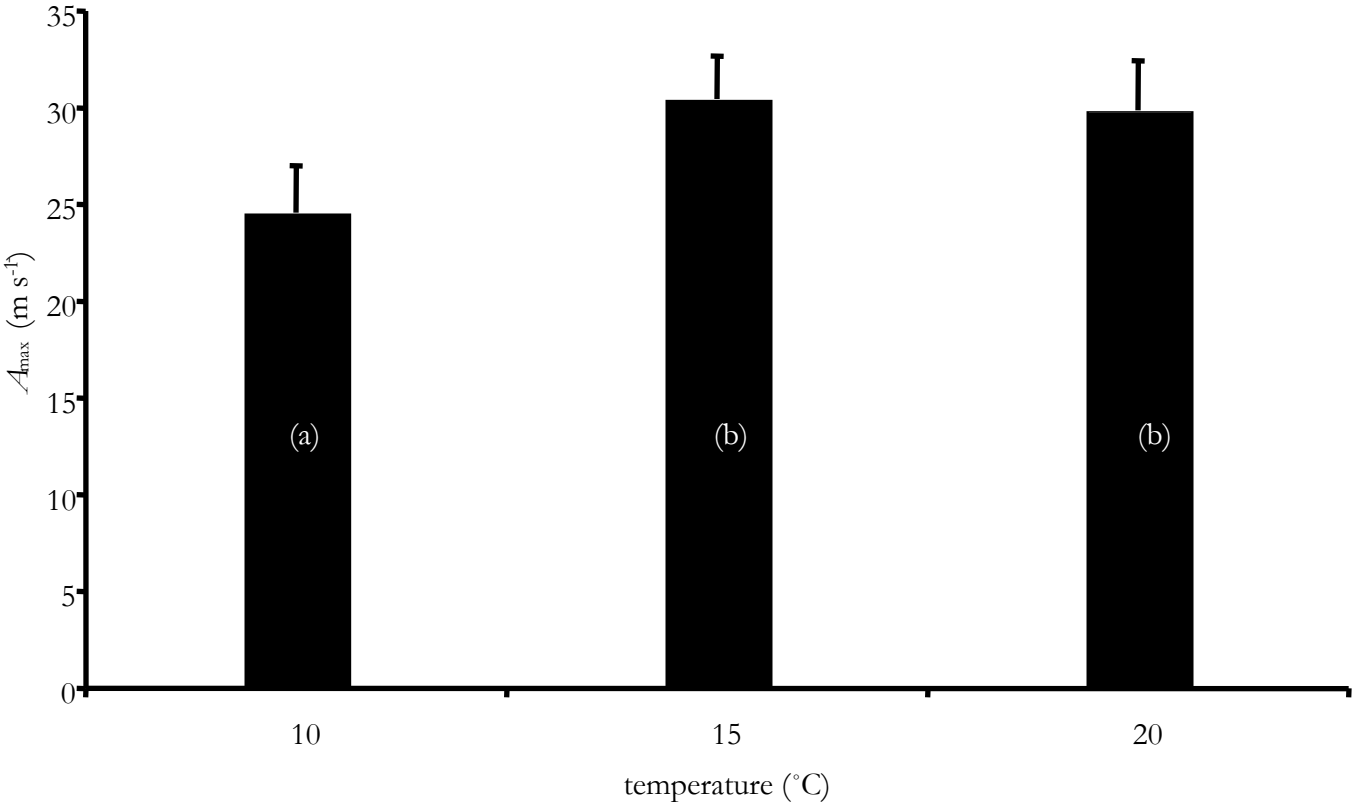


Results

Acceleration of Bursts



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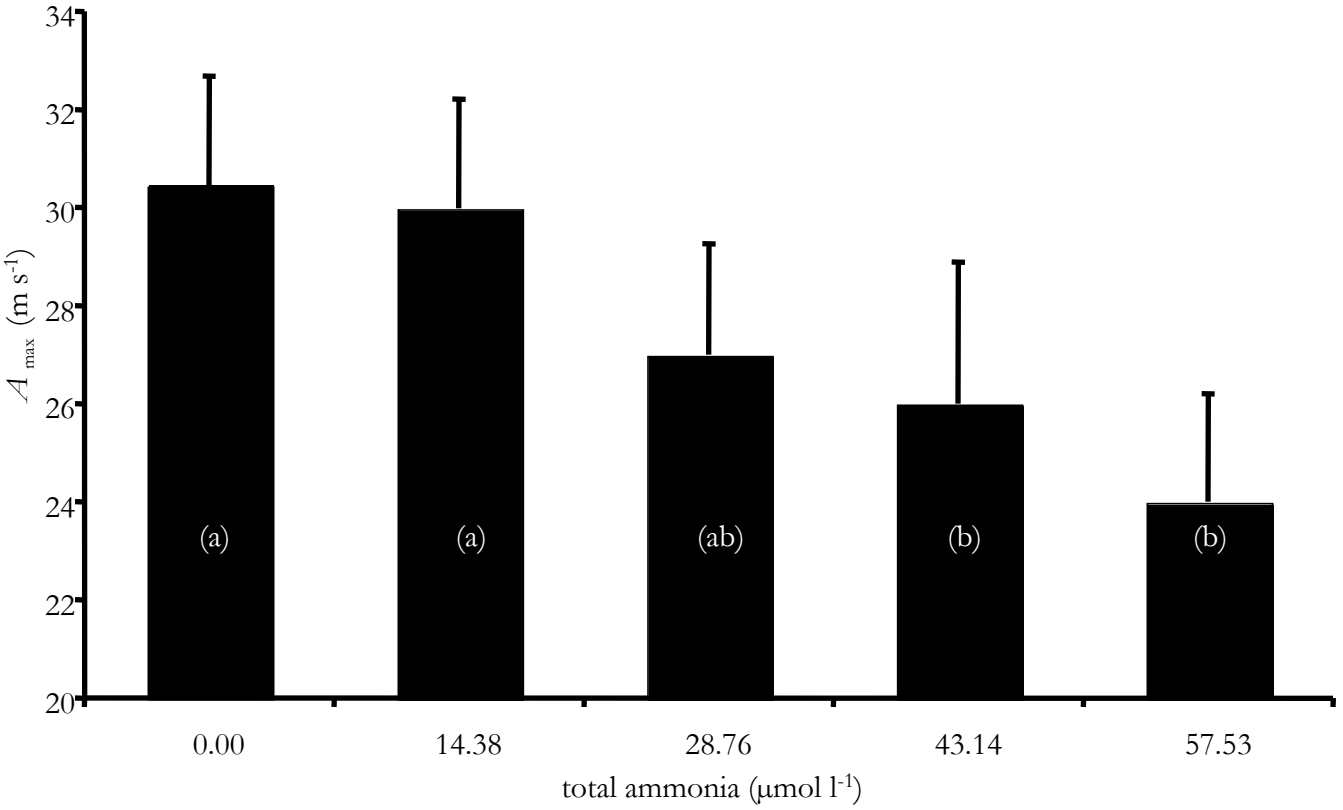
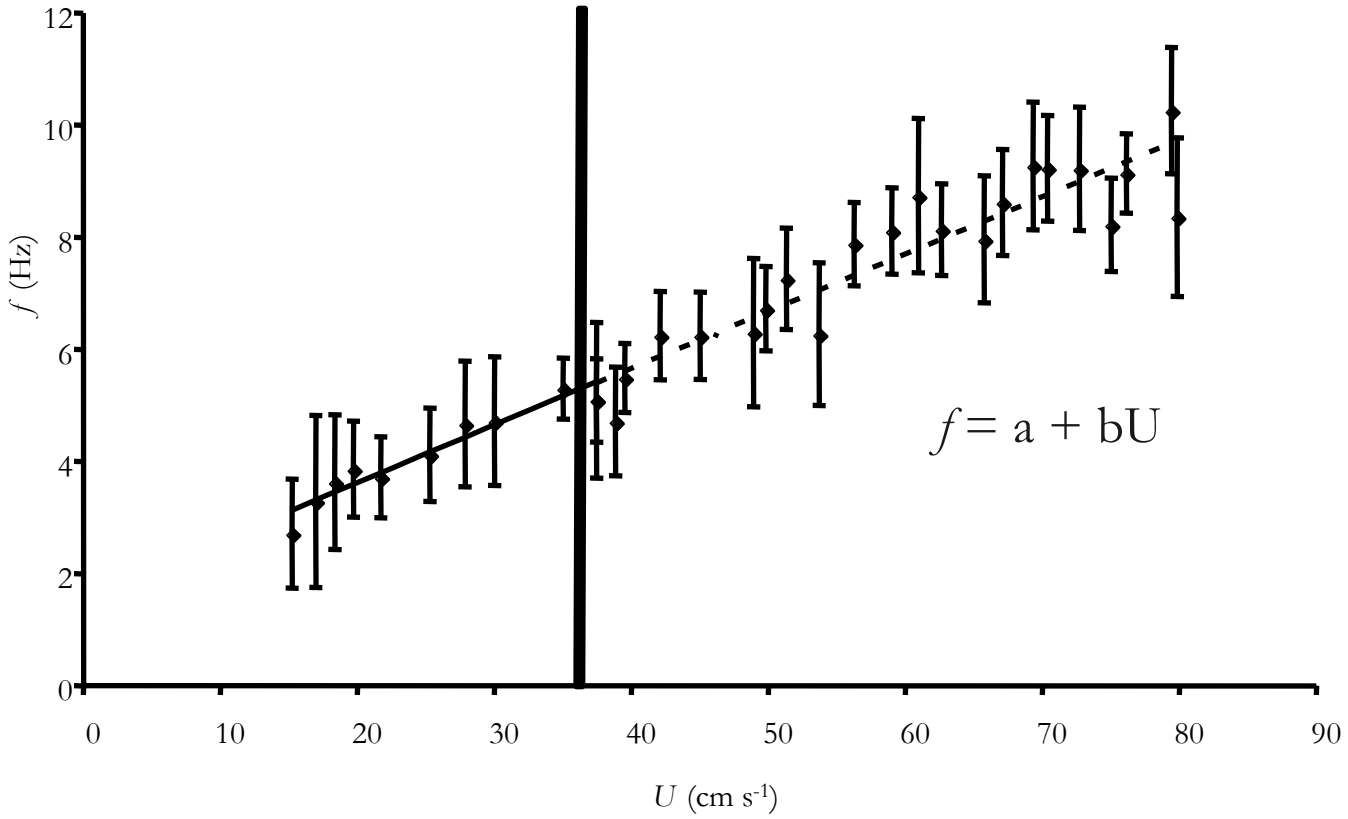


Results

Tail Beat Frequency

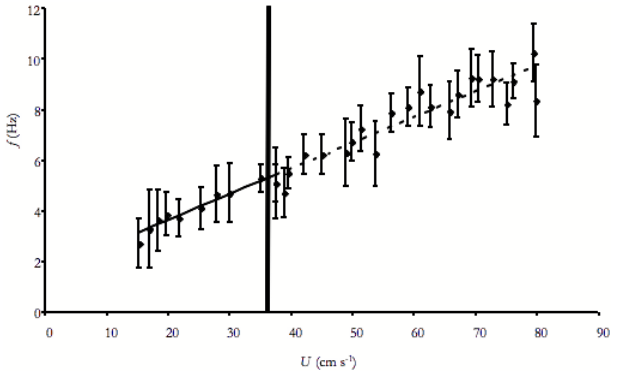


Tail Beat Frequency

$f = a + bU$

NO effect of temperature

effect of ammonia concentration:



conc.(µmol l^{-1})	0 (control)	14.38	28.77	43.15	57.53
a (before U_{gt})	1.57 ± 0.14	1.61 ± 0.15	1.58 ± 0.13	1.54 ± 0.17	1.53 ± 0.12
a (after U_{gt})	1.56 ± 0.11	1.57 ± 0.09	1.58 ± 0.12	0.48 ± 0.13*	0.24 ± 0.16*
b (before U_{gt})	0.104 ± 0.031	0.111 ± 0.025	0.112 ± 0.020	0.113 ± 0.012	0.118 ± 0.013
b (after U_{gt})	0.106 ± 0.024	0.106 ± 0.032	0.113 ± 0.024	0.125 ± 0.014*	0.130 ± 0.016*

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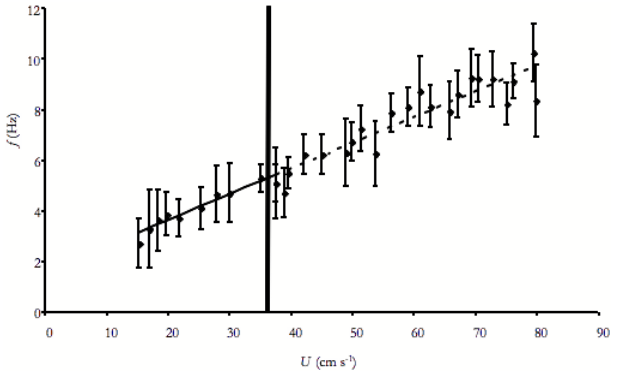

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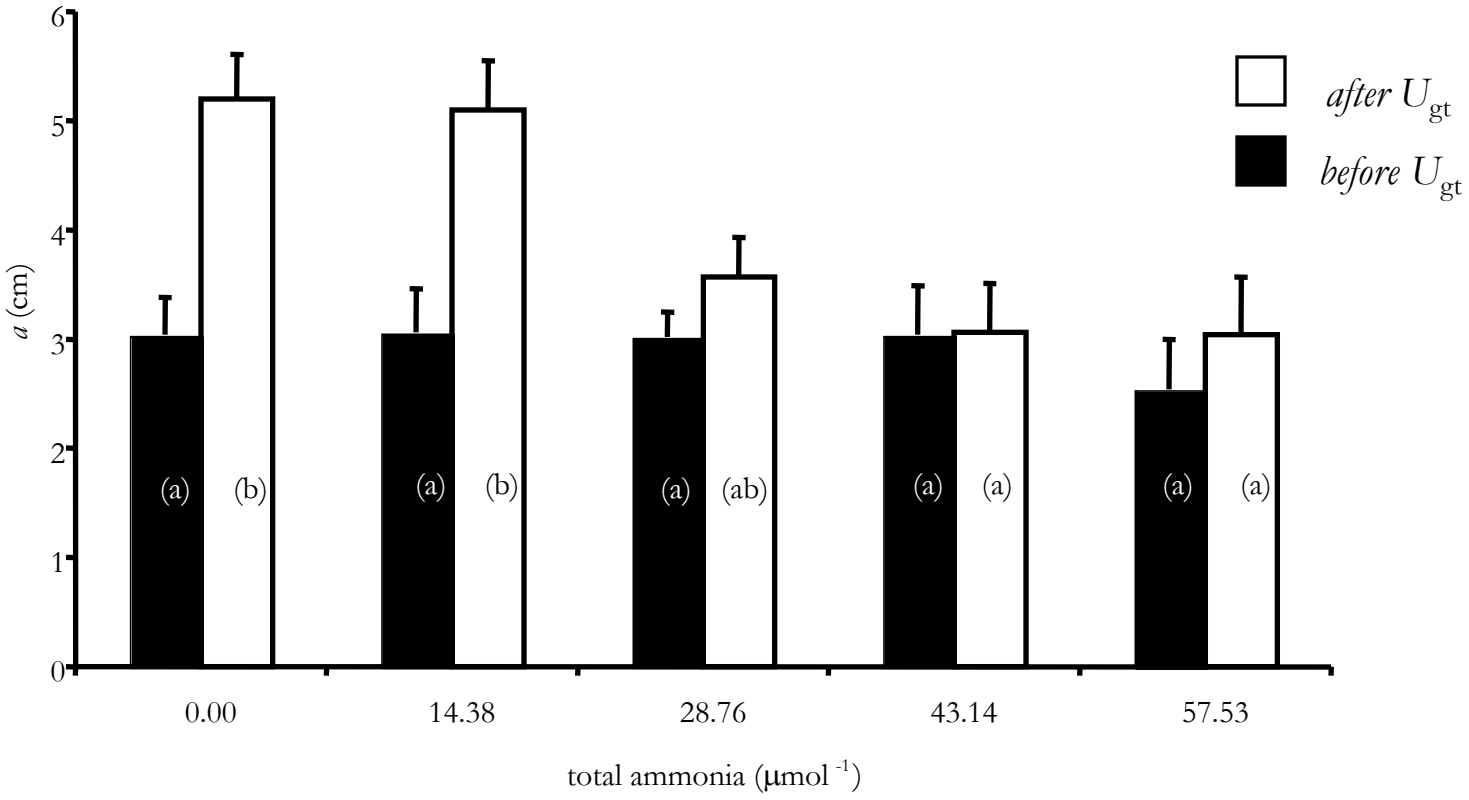
Tail Beat Amplitude



Conclusions

temperature change

gait transition speed (U_{trans}) reduced
aerobic swimming parameter

U_{max}, A_{max}, a, f not affected
anaerobic swimming parameter

Conclusions

elevated ammonia levels

gait transition speed (U_{trans}) not affected

aerobic swimming parameter

U_{max}, A_{max}, a reduced

anaerobic swimming parameter

f altered after U_{trans}

increased slope of burst-and-coast indicates increased cost of transport

Conclusions

altered temperature affects swimming parameters associated with aerobic swimming

elevated ammonia levels affect parameters associated with anaerobic swimming

traditional U_{crit} tests combine aerobic and anaerobic swimming

different environmental factor affect different swimming parameters

Conclusions

tilted flume good tool for inducing natural swimming behaviour

allows elaborated analysis of swimming parameters

U_{trans} valuable alternative

management purposes

Acknowledgements

Inge Findorf, Charles Sacoby, Paul Webb, Jon Peake

Manitoba Hydro
Oranjewoud B.V.

- Effects of Temperature and Ammonia on Swimming Capacity -